TMDL FOR PHOSPHORUS IN OSAGE CREEK NEAR BERRYVILLE, AR

(Reach 11010001-045L)

FINAL
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TMDL FOR PHOSPHORUS IN OSAGE CREEK NEAR BERRYVILLE, AR (Reach 11010001-045L)

Prepared for

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Water Quality Protection Division
Permits, Oversight, and TMDL Team
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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily pollutant loads for those waterbodies. A total maximum daily load (TMDL) is the amount of a pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be allocated to point sources and nonpoint sources discharging to the waterbody.

This report presents a TMDL for phosphorus for Osage Creek downstream of Berryville (Reach 11010001-045L) in the Kings River basin in northwest Arkansas. The upper end of the Osage Creek watershed is in the Boston Mountains ecoregion, but most of the watershed (including the impaired reach) is in the Ozark Highlands ecoregion. The Osage Creek watershed is approximately 98% forest and pasture. Osage Creek flows into the Kings River, which flows into Table Rock Lake in Missouri. The Osage Creek watershed has a drainage area of 164 square miles at its mouth.

The Environmental Protection Agency (EPA) Region 6 added this stream reach to the final 2002 Arkansas 303(d) list for not supporting its aquatic life designated use. Based on information in the Arkansas Department of Environmental Quality (ADEQ) 2002 Integrated Assessment Report and the EPA Decision Document for the final 2002 Arkansas 303(d) list, the primary cause of impairment is total phosphorus and the primary source of elevated phosphorus concentrations is the City of Berryville wastewater treatment plant (WWTP).

Arkansas has no numeric water quality criterion for phosphorus. Previous versions of Arkansas Regulation No. 2 included a guideline of 0.1 mg/L for total phosphorus in streams. Although this guideline was never a numeric criterion, it was still considered to be a reasonable benchmark for evaluating phosphorus levels in streams for the protection of aquatic life. The guideline of 0.1 mg/L was used as the target concentration, or endpoint, for this TMDL.

Historical monitoring data for phosphorus have been collected by ADEQ in Osage Creek upstream of Berryville (WHI0068) and downstream of Berryville (WHI0069). These data were

summarized and plotted. In general, concentrations of total phosphorus tended to be higher at the downstream station.

The TMDL in this report was developed for average annual conditions because aquatic life impairments typically occur as a result of long term exposure to elevated nutrient concentrations rather than short term increases in nutrient concentrations. The TMDL was developed using a simple mass balance approach assuming conservative mixing. Ten percent of the allowable loading was set aside as an explicit margin of safety.

A wasteload allocation (WLA) was developed for total phosphorus discharged from two point sources (City of Berryville and Bedford Falls Mobile Home Park). The allowable load for the City of Berryville was based on an effluent concentration of 1 mg/L as required in Arkansas Regulation No. 6. This will require the City of Berryville WWTP to reduce its current phosphorus load by approximately 85%. Because the discharge from the Bedford Falls Mobile Home Park is very small, its allowable loading was based on its estimated current loading. Two other point sources in the segment (Carroll County Stone, and Carroll Electric Cooperative) were excluded from the WLA because they do not have a source of phosphorus in their discharges.

The load allocation (LA) for nonpoint sources was calculated as the TMDL minus the MOS and WLA. This allowable nonpoint source load was compared to the existing nonpoint source load, which was calculated as the mean phosphorus concentration upstream of Berryville multiplied by the average annual ambient flow from the watershed. Comparing these allowable and existing loads showed that no reductions of nonpoint source loads of phosphorus are needed.

The components of this TMDL are summarized in Table ES.1.

Table ES.1. Osage Creek total phosphorus TMDL.

Allocation	Load (lbs/day)
WLA for point sources	22.44
LA for nonpoint sources	64.54
MOS	9.66
TMDL	96.64

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1.0 INTRODUCTION

This report presents the total maximum daily load (TMDL) for phosphorus for Osage Creek downstream of Berryville (stream segment 11010001-045L), which is located in the Kings River basin in northwest Arkansas. This stream segment was included on the Arkansas final 2002 Section 303(d) list (Environmental Protection Agency (EPA) 2003) for not supporting its aquatic life designated use (Table 1.1). Phosphorus is listed as the suspected cause of this impairment in the 303(d) list. According to the Arkansas Department of Environmental Quality (ADEQ) 2002 integrated assessment report (ADEQ 2002), the suspected primary source of elevated phosphorus concentrations in Osage Creek is the Berryville municipal wastewater treatment plant (WWTP).

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standards for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern and the LA is the load allocated to nonpoint sources and natural background. The MOS is a percentage of the TMDL that takes into account any lack of knowledge concerning the relationship between pollutant loadings and water quality.

Table 1.1. 303(d) listing for the stream reach in this task order (EPA 2003, ADEQ 2002).

Reach No.	Stream Name	Impaired Use	Source	Cause	Priority
11010001-045L	Osage Creek	Aquatic Life	Municipal Point Source	Total Phosphorus	High

2.0 BACKGROUND INFORMATION

2.1 General Information

The study area for the TMDL in this report is the Osage Creek watershed located in Carroll County in northwest Arkansas (see Figure A.1 located in Appendix A). Osage Creek drains in a generally northwesterly direction before joining the Kings River east of Berryville. The Kings River then flows into Table Rock Lake in Missouri. The impaired portion of Osage Creek is from Berryville (where the municipal WWTP effluent enters Osage Creek) to the mouth.

The upper end of the Osage Creek watershed is in the Boston Mountains ecoregion, but most of the watershed (including the impaired reach) is in the Ozark Highlands ecoregion. The Osage Creek watershed is also part of ADEQ Planning Segment 4K and US Geological Survey (USGS) Hydrologic Unit 11010001. The drainage area for Osage Creek at its mouth is 164 square miles.

Additional background information for the Osage Creek watershed (topography, soils, geology, etc.) is documented in a watershed assessment report that was prepared for the Kings River Watershed Partnership (KRWP) (FTN Associates, Ltd. (FTN) 2005).

2.2 Land Use

Land use/land cover data for the Osage Creek watershed were obtained from the University of Arkansas Center for Advanced Spatial Technologies (CAST) (2001). These data were based on satellite imagery from 1999, but they were compared with aerial photography in certain areas because of known growth in development during the last few years, particularly around Berryville. For example, in Berryville during 1 year (2004), construction permits were issued for 27 single family dwellings, 2 duplexes, 6 four-plexes, 9 commercial buildings, and 86 miscellaneous structures (primarily storage buildings and fences) (Carroll County News 2005). Because of this development, the most recent aerial photography (2002) was obtained and used to identify areas of new construction or other development that occurred after the published land

use/land cover data were developed. As a result of this review, the land use/land cover data were changed to urban for a number of small areas in the Berryville area.

These updates of the urban area did not significantly affect the overall land use statistics for the Osage Creek watershed. A map of land uses for the watershed is included as Figure A.2 (located in Appendix A) and land use statistics for the watershed are presented in Table 2.1.

Table 2.1. Land use/land cover percentages for the Osage Creek watershed.

Land use category	Percentage of watershed
Urban	1.3%
Water	0.3%
Forest	67.1%
Pasture/hay/grass	31.3%
TOTAL	100.0%

2.3 Description of Hydrology

Average annual precipitation ranges from 48 inches in the southern part of the watershed to 44 inches in the northern part of the watershed (USGS 1985). Approximately 35% of this precipitation becomes streamflow (USGS 1985). There is no USGS flow gage in the Osage Creek watershed, but the USGS maintains a continuous flow gage on the Kings River near Berryville (Gage # 07050500), about 5.6 miles downstream of the mouth of Osage Creek. Published daily flow data for this gage are currently available from April 1939 to September 1975 and from October 1992 to September 2004 (USGS 2005). The long term average flow for this gage is 576 cfs and its drainage area is 527 square miles (USGS 2005).

2.4 Water Quality Standards

The water quality standards for Osage Creek are given in Arkansas Regulation No. 2 (Arkansas Pollution Control and Ecology Commission (APCEC) 2004a). The designated uses for Osage Creek are primary contact recreation; secondary contact recreation; domestic, industrial and agricultural water supply; and perennial fishery (where the drainage area is at least 10 square miles).

For nutrients, the Arkansas water quality standards have narrative criteria but not a numeric criterion. The narrative criteria for nutrients in Arkansas are as follows:

> "Materials stimulating algal growth shall not be present in concentrations sufficient to cause objectionable algal densities or other nuisance aquatic vegetation or otherwise impair any designated use of the waterbody. Impairment of a waterbody from excess nutrients are dependent on the natural waterbody characteristics such as stream flow, residence time, stream slope, substrate type, canopy, riparian vegetation, primary use of waterbody, season of the year and ecoregion water chemistry. Because nutrient water column concentrations do not always correlate directly with stream impairments, impairments will be assessed by a combination of factors such as water clarity, periphyton or phytoplankton production, dissolved oxygen values, dissolved oxygen saturation, diurnal dissolved oxygen fluctuations, pH values, aquatic-life community structure and possibly others. However, when excess nutrients result in an impairment, based upon Department assessment methodology, by any established, numeric water quality standard, the waterbody will be determined to be impaired by nutrients."

The upper White River basin (including the Osage Creek watershed) has also been designated as a nutrient surplus area by the Arkansas Natural Resources Commission (ANRC 2005) due to concerns about excessive nutrient loads to streams and lakes. ANRC's regulations require poultry operations with 2,500 or more birds in nutrient surplus areas to register each year with ANRC. For point source dischargers in nutrient surplus areas, Regulation No. 2 also specifies the following requirements:

> "All point source discharges into the watershed of waters officially listed on Arkansas' impaired waterbody list (303d) with phosphorus as the major cause shall have monthly average discharge permit limits no greater than those listed below. Additionally, waters in nutrient surplus watersheds as determined by Act 1061 of 2003 Regular Session of the Arkansas 84th General Assembly and subsequently designated nutrient surplus watersheds may be included under this Reg. if point source discharges are shown to provide a significant phosphorus contribution to waters within the listed nutrient surplus watersheds.

Facility Design Flow	Total Phosphorus discharge limit
15 MGD or more	Case by case
3 to <15 MGD	1.0 mg/L
1 to <3 MGD	2.0 mg/L
0.5 to <1.0 MGD	5.0 mg/L
<0.5 MGD	Case by case

> "For discharges from point sources which are greater than 15 MGD, reduction of phosphorus below 1 mg/L may be required based on the magnitude of the phosphorus load (mass) and the type of downstream waterbodies (e.g., reservoirs, Extraordinary Resource Waters). Additionally, any discharge limits listed above may be further reduced if it is determined that these values are causing impairments to special waters such as domestic water supplies, lakes or reservoirs or Extraordinary Resource Waters."

In Arkansas Regulation No. 6, Chapter 4, it is stated that "No permit for discharge of domestic wastewater to Osage Creek or its tributaries, by the City of Berryville, shall authorize more than 1.0 mg/L Total Phosphorus based on a monthly average." Compliance with this requirement "shall be attained as soon as feasible, but no later than January 1, 2012" (APCEC 2004b).

Because Osage Creek flows into the Kings River, which flows into Missouri, water quality standards for the Kings River in Missouri are relevant to this TMDL. Currently the Missouri water quality standards do not have a numeric instream criterion for phosphorus for the Kings River in Missouri.

As specified in EPA's regulations at 40 CFR 130.7(b)(2), applicable water quality standards include antidegradation requirements. Arkansas' antidegradation policy is listed in Sections 2.201 through 2.204 of Regulation No. 2. These sections impose the following requirements:

- Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.
- Water quality that exceeds standards shall be maintained and protected unless allowing lower water quality is necessary to accommodate important economic or social development, although water quality must still be adequate to fully protect existing uses.
- For outstanding state or national resource waters, those uses and water quality for which the outstanding waterbody was designated shall be protected.
- For potential water quality impairments associated with a thermal discharge, the antidegradation policy and implementing method shall be consistent with Section 316 of the Clean Water Act.

2.5 Nonpoint Sources

A recent study of the Kings River watershed (FTN 2005) included a detailed investigation of phosphorus loading by subwatershed. Nonpoint sources of phosphorus load that were identified in the Osage Creek subwatershed included livestock (beef and dairy cattle), application of poultry litter to pasture, on-site wastewater systems (i.e. septic tanks), and streambank erosion. Beef and poultry production is fairly common in the Osage Creek watershed, and runoff from pasture was estimated to be the greatest potential nonpoint source of phosphorus in the watershed (FTN 2005).

2.6 Point Sources

Point source discharges in the Osage Creek watershed were identified using EPA's Permit Compliance System (PCS) web site (EPA 2005). According to PCS, there are a total of four facilities in the watershed with point source discharges that are permitted through the National Pollutant Discharge Elimination System (NDPES). Information for these facilities is summarized in Table 2.2 and locations of these facilities are shown on Figure A.3. None of the facilities currently has a permit limit for phosphorus, although, as noted in Section 2.4 above, the City of Berryville is required under Regulation 6 to reduce phosphorus discharge to a 1 mg/L monthly average by no later than 2012.

The largest point source discharge in the Osage Creek watershed is the City of Berryville wastewater treatment plant (WWTP), which has a treatment system that includes two oxidation ditches, two final clarifiers, and ultraviolet disinfection with land application of sludge on permitted farms near the WWTP. The City of Berryville is planning changes to the treatment system that could reduce effluent concentrations of phosphorus and sludge volume. The Berryville WWTP receives wastewater from a Tyson poultry processing facility in addition to domestic wastewater from residences. Although the Tyson facility uses pretreatment to decrease pollutant concentrations in their wastewater, personnel at the City of Berryville WWTP have estimated that approximately 70% to 80% of their incoming load of biochemical oxygen demand (BOD) and ammonia comes from the Tyson facility (FTN 2005).

Table 2.2. Point source discharges in the Osage Creek watershed.

NPDES Number	Facility Name	Design Flow (MGD)	Parameter	Monthly Average Permit Limits (mg/L)
AR0021792	City Of Berryville WWTP	2.4	BOD5	15 (summer), 20 (winter)
			TSS	20 (summer), 30 (winter)
			NH3-N	2 (summer), 10 (winter)
			Total Phos	not in permit
AR0044059	Carroll Electric Cooperative	0.0020	CBOD5	25
			TSS	90
			NH3-N	5
			Total Phos	not in permit
AR0047619	Carroll County Stone	0.0364	CBOD5	not in permit
			TSS	35
			NH3-N	not in permit
			Total Phos	not in permit
AR0049867	Bedford Falls Mobile Home Park	0.0387	CBOD5	15
			TSS	20
			NH3-N	5 (summer), 10 (winter)
			Total Phos	not in permit

The City of Berryville WWTP and the Bedford Falls Mobile Home Park were the only two point sources discharges included in the TMDL calculations because it was assumed that the other two discharges did not have any source of phosphorus in their discharges.

2.7 Previous Studies

2.7.1 Parsons/UA Study

During 2003 and 2004, Parsons and the University of Arkansas at Fayetteville (UA) conducted a comprehensive survey of the Kings River and Illinois River watersheds, which included looking at water quality, fish and benthic communities, and habitat and streambed characteristics at two sites on Osage Creek (shown on Figure A.4) (Parsons/UA 2004). The water quality sampling showed increases of nitrite + nitrate, total nitrogen, orthophosphorus, and total phosphorus in Osage Creek downstream of the discharge from the City of Berryville WWTP. The stream habitats at the sampling sites were characterized as unimpacted. The biological data collection showed some evidence of impacts during at least one sampling event at each of the sampling sites. The water chemistry data, physical habitat data, and biological data were

combined to classify each sampling site concerning the level of impacts to aquatic life. As shown in Table 2.3, the site on Osage Creek downstream of Berryville was classified as severely impacted and the site on Osage Creek upstream of Berryville was classified as unimpacted.

2.7.2 ADEQ Water Quality Survey of White River

During 1992 and 1993, ADEQ conducted a water quality survey of the upper White River that included five sampling sites on Osage Creek. Four of these sampling sites were located upstream of Berryville, and the fifth was the ADEQ routine ambient water quality sampling site located downstream of Berryville (WHI0069). Seven sampling events were conducted and included water quality and macroinvertebrate sampling on Osage Creek. Nutrient analysis of the water quality samples indicated that the Berryville WWTP was contributing significant nutrient loads to Osage Creek (ADEQ 1995). A dairy farm upstream of Berryville was also identified as a possible cause of elevated phosphorus concentrations observed in Osage Creek (station OSG03) (ADEQ 1995). Macroinvertebrates were sampled at two of the Osage Creek sampling sites, both upstream of Berryville. One of these sites indicated slight impairment due to habitat.

Table 2.3. Conclusions for Osage Creek sampling stations from Parsons/UA study.

Station ID	Sampling event	Water Chemistry					Habitat		Biological				Total number of indicators impacted	Conclusion (based on all events)
		DO minimum	DO fluctuation	DO saturation	Total phos.	TDS	Riffle	Pool	Periphyton	Filamentous	Benthics	Fish		
OSG045UP (Osage Creek upstream of Berryville)	1	○	○	○	○	○	○	○	○	**x**	○	**x**	3	Unimpacted
	2	○	○	○	○	○	○	○	-	-	-	○		
	3	**x**	○	○	○	○	-	-	-	-	-	-		
OSG045DN (Osage Creek downstream of Berryville)	1	**x**	**x**	○	**x**	**x**	○	○	○	**x**	**x**	○	16	Severely impacted
	2	○	**x**	**x**	**x**	**x**	○	○	-	-	**x**	**x**		
	3	○	**x**	**x**	**x**	**x**	-	-	-	-	-	-		

x = impacted, o = not impacted

2.7.3 ADEQ Water Quality Survey Freeman Branch and Osage Creek

In 1991 ADEQ conducted an investigation of water quality effects of the Berryville WWTP effluent on Freeman Branch (the receiving waterbody for City of Berryville WWTP) and Osage Creek (ADEQ 1992). One sampling station was located on Freeman Branch and four sampling stations were located on Osage Creek, one upstream of Freeman Branch and three downstream. Fish and macroinvertebrates were sampled on Freeman Branch and at two sites on Osage Creek, one upstream and one just downstream of Freeman Branch. Water quality samples were analyzed for nitrogen but not phosphorus. The nitrogen and dissolved oxygen results indicated nutrient related impacts in Freeman Branch and Osage Creek downstream of Freeman Branch. The Freeman Branch macroinvertebrates samples indicated impairment, as did the fish community samples. Osage Creek Macroinvertebrate and fish samples did not indicate impairment.

2.7.4 Kings River Watershed Assessment

In 2005, FTN compiled an assessment of the Kings River Watershed for the Kings River Watershed Partnership (FTN 2005). This assessment evaluated the effects of streambank erosion, road and ditch erosion, pasture and forest management, septic tanks, urban runoff, construction site erosion, and point source discharges on the total phosphorus load in the Kings River. Poultry litter and erosion of phosphorus-bound sediment were determined to be the major nonpoint sources of phosphorus loads while the City of Berryville sewage treatment plant was identified as the major point source of phosphorus loads.

3.0 EXISTING WATER QUALITY

3.1 General Description of Data

Historical water quality data have been collected by ADEQ at approximately monthly intervals for two locations in Osage Creek. The locations of these sampling stations are shown on Figure A.4. Table 3.1 summarizes the ADEQ total phosphorus data collected at these two sites.

Table 3.1. Summary of ADEQ total phosphorus data for Osage Creek.

Station	Begin	End	Count	Min	Avg	Median	Max
Osage Creek above Berryville (WHI0068)	11/21/83	10/19/04	229	0.003	0.050	0.036	0.92
Osage Creek below Berryville (WHI0069)	11/21/83	10/19/04	197	0.010	1.049	0.410	24.62

3.2 Long Term Trends

Time series plots of ADEQ measurements of total phosphorus over the period of record are included in Appendix B. For the most part, these data do not show noticeable trends in water quality. This is not unexpected, since there has been relatively little change in land use in the watershed over the sampling period of record. For Osage Creek below Berryville (Station WHI0069), total phosphorus concentrations appear to have been higher during the period from about 1994 through 2002 than they had been in the 1980's; however the 2003 and 2004 concentrations appear similar to the 1980's levels (Figures B.1 and B.2).

3.3 Seasonal Patterns

Seasonal plots of ADEQ measurements of total phosphorus over the period of record are shown in Figures B.3 and B.4 (in Appendix B). Time series plots of KRWP measurements of phosphorus are shown in Figures B.5 and B.6. Since just one year of KRWP data are plotted, these plots are similar to the seasonal plots. For the most part, these data do not show noticeable seasonal patterns in water quality. Patterns that are apparent are discussed below:

- For Osage Creek below Berryville (Station WHI0069), total phosphorus concentrations tend to be lower in January through April than during the rest of the year (Figure B.4). This pattern may be the result of one or two years of data with higher concentrations during this period.
- For Lower Osage Creek at CR 306 (KRWP station #2), phosphorus concentrations are higher in the late summer – fall than during the rest of the year (Figure B.6). This pattern is similar to the pattern of the phosphorus data from station WHI0069, which is just upstream (see above).

3.4 Relationship to Flow

Figures B.7 and B.8 (in Appendix B) show plots of ADEQ data for total phosphorus versus flows estimated from measured data for the Kings River near Berryville (USGS Gage 07050500). The data upstream of Berryville do not show a noticeable correlation between flow and water quality. For Osage Creek below Berryville (station WHI0069), the highest total phosphorus concentrations occur during the lowest flows (Figure B.8). This type of correlation between concentration and flow suggests that the highest phosphorus concentrations are coming from a point source. The higher phosphorus concentrations at this station are occurring when there is the least amount of dilution water in Osage Creek.

4.0 TMDL DEVELOPMENT

4.1 Seasonality and Critical Conditions

EPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Also, both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to consider seasonal variations for meeting water quality standards. Aquatic life impairments typically occur as a result of long term exposure to elevated nutrient concentrations rather than short term fluctuations in nutrient concentrations. This phosphorus TMDL was developed for average annual conditions. These nutrient TMDLs were developed for average annual conditions. The most obvious result of nutrients is algal blooms. When the algae die, the resultant biological oxygen demand consumes oxygen, which adversely affects aquatic life. The effect occurs in a short time but the build-up of nutrients and the conditions to start the algal bloom may occur over an extended time.

4.2 Water Quality Targets

As mentioned in Section 2.4, the Arkansas water quality standards do not include a numeric criterion for phosphorus. At the time when this reach of Osage Creek was first added to the 303(d) list for phosphorus, Arkansas Regulation No. 2 contained a numeric guideline for total phosphorus of 0.1 mg/L for streams. Although the current version of Regulation No. 2 no longer includes that guideline, it is still considered a reasonable benchmark for evaluating phosphorus levels in streams for the protection of aquatic life. The total phosphorus concentration of 0.1 mg/L was used as the target concentration, or numeric endpoint, for this phosphorus TMDL.

4.3 TMDL

The first step in developing the components of the phosphorus TMDL was to calculate the assimilative capacity for the segment. The assimilative capacity for the segment was calculated by simply multiplying the target phosphorus concentration (0.1 mg/L) by the total flow in the stream for the segment and the appropriate conversion factor. The total flow in the

segment was calculated as the average annual ambient flow from the watershed plus the design flows of both point sources that have phosphorus in their discharge (City of Berryville WWTP and Bedford Falls Mobile Home Park). The average annual ambient flow for the segment was estimated as the average annual flow per unit area for the USGS gage on the Kings River (1.09 cfs per square mile) times the drainage area of the segment (164 square miles) minus the historical average contribution of the point source discharge to the USGS measured flows (2.12 MGD). This resulted in average annual ambient flow rate of 175.5 cfs, or 113.4 MGD. Including the combined design flows from the point source discharges (2.4387 MGD), the total average annual flow for the segment is 115.9 MGD. When this total flow was multiplied by the target concentration, the resulting value for assimilative capacity was 96.64 lbs/day of total phosphorus. The TMDL was set equal to the assimilative capacity.

4.4 Margin of Safety

The next step was to account for the MOS. Both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to include a MOS to account for lack of knowledge concerning the relationship between pollutant loadings and water quality. The MOS may be expressed explicitly as unallocated assimilative capacity or implicitly through conservative assumptions used in establishing the TMDL. For this phosphorus TMDL, 10% of the assimilative capacity (i.e., 9.66 lbs/day) was set aside as an explicit MOS. In addition to the explicit MOS, this TMDL also includes an unquantified implicit MOS due to the calculation of loads assuming that both point sources are simultaneously discharging at design capacity.

4.5 Wasteload Allocation

After subtracting the MOS from the TMDL, allowable point source loads were calculated. An effluent phosphorus concentration of 1 mg/L was used for the City of Berryville based on requirements in Arkansas Regulation No. 6. For the Bedford Falls Mobile Home Park, an effluent phosphorus concentration of 7.5 mg/L was used because its effluent phosphorus concentration was assumed to be similar to the current effluent concentration that was back-calculated for the City of Berryville (FTN 2005). Because the Bedford Falls Mobile Home

Park is very small, its allowable load was based on its estimated current load with no reductions. Each point source load was calculated as the design flow multiplied by the effluent concentration and the appropriate conversion factor. The resulting allowable loads of total phosphorus were 20.02 lbs/day for the City of Berryville and 2.42 lbs/day for the Bedford Falls Mobile Home Park. The allowable effluent concentrations and loads are shown in Table 4.1.

Table 4.1. Summary of allowable point source concentrations and loads.

	Total Phosphorus Loads	
	(mg/L)	(lbs/day)
City of Berryville WWTP (AR0021792)	1.0	20.02
Bedford Falls Mobile Home Park (AR0049867)	7.5	2.42
Carroll County Stone (AR0047619)	NA	NA
Carroll Electric Cooperative (AR0044059)	NA	NA

Based on recent effluent phosphorus loads that were back-calculated for the City of Berryville WWTP (134 lbs/day; FTN 2005), the City of Berryville WWTP will need to reduce its phosphorus load by approximately 85% to comply with this TMDL.

4.6 Load Allocation

The LA for nonpoint source loading from the watershed was calculated as the remaining available load after the MOS and WLA were subtracted from the TMDL. The LA was calculated to be 64.54 lbs/day.

In order to calculate a percent reduction that would be needed for nonpoint source loads, the existing nonpoint source load was calculated as the mean concentration of total phosphorus at ADEQ Station WHI0068 (0.050 mg/L; see Table 3.1) times the average annual ambient flow for the segment (113.4 MGD) and the appropriate conversion factor. This yielded an existing load of 47.3 lbs/day. Because this existing nonpoint source load is smaller than the allowable nonpoint source load (64.54 lbs/day), no nonpoint source reductions are required.

The LA and other components of the TMDL are summarized in Table 4.2.

Table 4.2. Osage Creek total phosphorus TMDL.

Allocation	Load (lbs/day)
WLA for point sources	22.44
LA for nonpoint sources	64.54
MOS	9.66
TMDL	96.64

4.7 Future Growth

Compliance with this TMDL for total phosphorus is based on keeping concentrations in the stream below the target concentrations rather than keeping the loads in the stream below a certain amount. The assimilative capacity of the stream will increase as the amount of flow in the stream increases. Increases in flow will allow for increased loadings of phosphorus to Osage Creek. Future growth for existing or new point sources discharging to Osage Creek is not limited by this TMDL as long as the point source(s) do not cause instream concentrations of total phosphorus to exceed the target concentration of 0.1 mg/L. At this time the instream criterion is the water quality target established in Section 4.2. In the future, the instream criterion may be set by an addition of a numeric criterion to the standard or other values set by a nutrient criteria setting procedure by ADEQ.

5.0 OTHER RELEVANT INFORMATION

In accordance with Section 106 of the Federal Clean Water Act and under its own authority, ADEQ has established a comprehensive program for monitoring the quality of the State's surface waters. ADEQ collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for long term trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (*Water Quality Inventory*) and the 303(d) list of impaired waters which is published as the 2002 Arkansas Integrated Water Quality Monitoring and Assessment Report (ADEQ 2002).

Point source reductions for this TMDL will be implemented through the NPDES program, which is administered by ADEQ in Arkansas.

6.0 PUBLIC PARTICIPATION

When EPA establishes a TMDL, federal regulations require EPA to publicly notice and seek comment concerning the TMDL. Pursuant to a May 2000 consent decree, this TMDL was prepared under contract to EPA. After development of the draft version of this TMDL, EPA prepared a notice seeking comments, information, and data from the general public and affected public. Comments were submitted during the public comment period and this TMDL has been revised accordingly. Responses to these comments are included in Appendix C. EPA has transmitted the revised TMDL to ADEQ for implementation and for incorporation into ADEQ's current water quality management plan.

7.0 REFERENCES

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